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12 July, 1996

Capt. Ed Marchand
AFCEE/ERT
3207 North Road, Bldg 532
Brooks AFB, Texas 78235-5363

Subject: Extended Bioventing Testing Results at Fire Training Area 2 (FTA-2),
Patrick Air Force Base (AFB); and FTA-2 and Facility 1748, Cape
Canaveral Air Force Station (AFS), Florida (Contract No. F41624-92-8036,
Order 17)

Dear Capt. Marchand:

Parsons Engineering Science, Inc. (Parsons ES) is pleased to submit the results of the extended bioventing testing at FTA-2, Patrick AFB, Florida; and FTA-2 and Facility 1748, Cape Canaveral AFS, Florida. Soil gas samples were collected and *in situ* respiration testing was performed by Parsons ES from 29 May to 2 June 1996 to assess the extent of remediation completed during approximately two years of air injection bioventing at these three sites. The purpose of this letter is to summarize site activities to date, present the results of the most recent respiration and soil gas sampling, and make recommendations based on site data. A site layout is attached for each of the three sites (Figures 1, 2, and 3), as are tables which summarize soil and soil gas analytical results and respiration and fuel biodegradation rates for the bioventing initiative and extended bioventing projects (Tables 1 through 9). In addition, a new monitoring point construction detail (Figure 4) is included for Facility 1748. Monitoring points at this site required modification (the addition of a shallow screened interval) to allow for soil gas sampling during the high water table conditions that currently exist.

SITE AND PROJECT HISTORY

Site Descriptions

FTA-2 Sites at Patrick AFB and Cape Canaveral AFS

The FTA-2 sites at Patrick AFB and Cape Canaveral AFS consist of unlined, earth-bermed circular burn pits measuring approximately 100 to 150 feet in diameter. These bermed areas were used from the mid-1960's to 1985 for fire control training exercises. A variety of combustible wastes (e.g., contaminated fuels and waste oils) were burned at these two sites, and no containment system was used to prevent direct infiltration of fuel into site soils. The unsaturated zone at the Patrick AFB FTA-2 site is approximately 4 feet thick, but fluctuates significantly with the changing water table surface. Groundwater at the Cape Canaveral AFS FTA-2 site generally fluctuates between 7 to 10 feet below ground surface (bgs).

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AQMD1-03-0421

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As determined by a Phase II study conducted by O'Brien & Gere Engineers, Inc., the primary contaminants at these two sites are petroleum hydrocarbons (1990). During this study, a maximum total recoverable petroleum hydrocarbons (TRPH) concentration of 38,200 milligrams per kilogram (mg/kg) was detected in surface soil samples at the Patrick AFB site. Soil samples collected from inside the Patrick AFB FTA-2 pit area and above groundwater, showed TRPH concentrations ranging from 9.83 to 16,700 mg/kg, with the majority of samples having concentrations in the several thousand mg/kg range.

At the Cape Canaveral AFS FTA-2 site, a maximum TRPH concentration of 43,100 mg/kg was detected in surface soils sampled in 1988 at a depth between 2 and 4 feet bgs. Soil samples collected inside the burn pit area and above the shallow aquifer showed TRPH concentrations from 4,750 to 43,100 mg/kg. Benzene, toluene, ethylbenzene, and xylenes (BTEX) were detected in soil and groundwater samples from each of the FTA-2 sites.

The FTA-2 site at Cape Canaveral is part of Installation Restoration Program (IRP) Site FT-17, which contains multiple areas of contamination, including a plume of chlorinated solvents in groundwater and a free product plume downgradient of the burn pit. The burn pit comprises only about 5 percent of the total area of the site.

Facility 1748 at Cape Canaveral AFS

Facility 1748 is a base cafeteria located within the industrial area of Cape Canaveral AFS. In 1958, when facility operation began, a 4,000-gallon underground storage tank (UST) was installed to store diesel fuel used for cafeteria boiler operation. The UST remained in operation until March 1992.

The primary contaminants at Facility 1748 are petroleum (diesel fuel) hydrocarbons which have been detected in the soils above groundwater. Groundwater at the site is encountered at fluctuating depths of 4 to 8 feet bgs across the site. During Phase I Assessment activities at the site in 1991, CH₂M Hill discovered excessively contaminated soils at depths between 2 and 6 feet bgs. Using an organic vapor analyzer (OVA) equipped with a flame ionization detector (FID), soil screening measurements of total hydrocarbon vapor ranged from 100 parts per million (ppm) to greater than 1,000 ppm. These measurements represent relatively high FID results for diesel fuel contaminated soils (CH₂M Hill, 1992).

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Project Overview

Bioventing Initiative

Initial bioventing pilot tests were completed by Parsons ES [formerly Engineering-Science, (ES), Inc.] at FTA-2, Patrick AFB, and FTA-2, Cape Canaveral AFS, between 11 March and 27 April 1993 (ES, 1993). The initial bioventing pilot test at Facility 1748, Cape Canaveral AFS, was completed between 30 December 1993 and 8 February 1994 (ES, 1994). The bioventing pilot tests were performed as part of the Air Force Center for Environmental Excellence (AFCEE) Bioventing Pilot Test Initiative (Contract No. F33615-90-D-4014, Order 14). Initial testing at each site included vent well (VW) and monitoring point (MP) construction, respiration and air permeability testing, soil and soil gas sampling, and blower system installation and startup. Under the initiative program, extended blower operation began in October 1993 for the Patrick AFB FTA-2 site and in May 1994 for the two Cape Canaveral AFS sites. To monitor remedial progress, 6-month and 1-year respiration testing was performed, and 1-year soil and soil gas sampling was completed at both FTA-2 sites. At Facility 1748, elevated water table conditions prevented 6-month and 1-year testing; and as a result, soil and soil gas sampling, and respiration testing were performed following 18 months of bioventing system operation.

Extended Bioventing

In September 1994, Parsons ES was awarded a task order from AFCEE (Contract No. F41624-92-D-8036 Order 17) to complete bioventing remediation monitoring and design and/or closure sampling, and to implement full-scale bioventing at several US Air Force sites. The purpose of the new task order is to extend the operation of existing bioventing pilot systems, and to move forward with either site closure or design and implementation of full-scale bioventing systems. Four potential options were identified for each site.

- Option 1 - An additional 1 year of testing for existing bioventing systems;
- Option 2 - Closure soil sampling for sites which have demonstrated bioventing success;
- Option 3 - Complete an initial bioventing test at a new site; and
- Option 4 - Design and installation of a multiple-vent well, full-scale bioventing system.

Parsons ES is currently contracted to perform Option 1 and Option 2 tasks at the two FTA-2 sites, and at Facility 1748. Options 1 and 2 were awarded on 30 September 1994 for Facility 1748 at Cape Canaveral AFS and FTA-2 at Patrick AFB, and on 31 March

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1995 for the FTA-2 site at Cape Canaveral AFS. Under Option 1, Parsons ES has been responsible for:

- Any major system repairs required over 1 year of extended system operation.
- Collecting laboratory soil gas samples for the analysis of total volatile hydrocarbons (TVH) and BTEX from the same monitoring point intervals that were sampled during the initial and final sampling events under the Bioventing Initiative Project.
- Performing respiration testing at the same monitoring points that were tested during the initial and final sampling events.
- Providing AFCEE and the Cape Canaveral AFS/Patrick AFB point of contact with a letter report summarizing the extended bioventing test results.

Under Option 2, Parsons ES is responsible for:

- Preparing a closure sampling and analysis plan.
- Performing closure soil sampling to demonstrate that site cleanup goals have been achieved.
- Preparing a soils "no further response action planned" decision document or a letter report summarizing sampling results.

Option 1 extended system operation at Facility 1748 and the Patrick AFB FTA-2 site was performed from 30 September 1994 to 25 April 1996. Option 1 extended system operation at the Cape Canaveral FTA-2 site was performed from 31 March 1995 to 25 April 1996. Bioventing systems at all three sites were shut down on 25 April 1996 and *in situ* respiration testing and soil gas sampling were conducted from 29 May to 2 June 1996. The bioventing systems at all three sites were shut down approximately 1 month prior to Option 1 testing to allow soils and soil gas to return to equilibrium conditions and allow comparison to baseline and previous test results. The latest round of testing and sampling occurred following approximately 2 years of system operation at the two Cape Canaveral AFS sites, and following 2.5 years of operation at the Patrick AFB FTA-2 site.

TESTING RESULTS

Unlike the initiative program where soil sample collection and analysis was performed prior to and following 1 year of bioventing system operation, Option 1

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testing under the extended program relies upon *in situ* respiration testing and soil gas sampling to assess the status of site remediation and readiness of the site for closure soil sampling activities, provided under Option 2. For each site, soil data from the initiative program is discussed, after which Option 1 testing results are presented.

FTA-2 - Patrick AFB

Initial and 1-year soil sample results at the Patrick AFB FTA-2 site are shown in Table 1. TRPH concentrations in site soils remained relatively high following the 1-year pilot test; however, a 25 to 50 percent decrease was indicated. BTEX concentrations in site soils were reduced 2 orders of magnitude to non-detect levels during the 1-year test. Soil contamination at the Patrick AFB FTA-2 is predominantly composed of higher molecular weight hydrocarbons which are detected in TRPH analyses. The overall degradation of TRPH concentrations in site soils typically occurs much more slowly than the degradation of the BTEX fraction.

Soil gas sampling was performed prior to initiating bioventing system operation and following 1 year and 2.5 years of system operation (Table 2). Reductions measuring 2 to 3 orders of magnitude were uniformly indicated in soil gas concentrations of TVH and BTEX following 1 year of system operation. Further reductions in soil gas BTEX and TVH concentrations as a result of extended system operation (Option 1) are more difficult to discern, with concentrations remaining low during the 2.5-year sampling event.

Respiration rates and fuel biodegradation rates at the Patrick AFB FTA-2 site have remained fairly consistent during 2.5 years of bioventing (Table 3). The rates shown reflect the ongoing oxygen utilization and petroleum hydrocarbon biodegradation associated with the remaining fuel residuals in site soils.

FTA-2 - Cape Canaveral AFS

Soil analytical results from sampling performed during the bioventing initiative program at FTA-2, Cape Canaveral AFS, are presented in Table 4. Soil concentrations of TRPH showed little or no change at this site during the first year of bioventing system operation (May 1994 to June 1995). TRPH soil concentrations measured at MPB-5.5 were actually higher at the 1-year sampling interval. However, soil concentrations of BTEX decreased by 2 orders of magnitude, resulting in no detectable BTEX concentrations. During the first year of bioventing system operation, the 5.5 to 6 foot depth interval, from which soil samples were collected, was submerged for a large portion of the test period. Elevated water table conditions during the first year had two significant effects on bioventing results at this soil interval. First, oxygen delivery to this interval occurred for a limited period of time, estimated to be less than

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6 months. As a result, oxygen delivery was sufficient for significant biodegradation of the lighter, more aromatic BTEX fuel hydrocarbons, but not for the more recalcitrant hydrocarbons measured by the TRPH analyses. Second, the 5.5- to 6-foot soil depth interval was influenced by sorption of dissolved fuel hydrocarbons to soils caused by fluctuating water table elevations. This smearing action may have masked TRPH degradation which occurred during the first year of system operation. Results of 1-year soil sampling indicate the need for continued oxygen delivery to soils at the Cape Canaveral AFS FTA-2 site.

Laboratory soil gas samples were collected from MPA-6, MPB-6, and MPC-6 at the Cape Canaveral AFS FTA-2 site on 29 May 1996. As evident from the sample results presented in Table 5, the majority of TVH and BTEX reduction occurred during the first year of bioventing system operation. Results indicate an approximate 2 orders of magnitude reduction in TVH and BTEX concentrations as compared to initial sample results from April 1993. The 2-Year TVH concentration from MPB-6 was significantly higher than the concentration measured after 1-year of air injection. This trend is similar to the increase in soil TRPH concentration seen in the 1-year soil sample from MPB (Table 4). One possible explanation for the elevated soil and soil gas results at MPB involves the ongoing intermittent detection of free-product at groundwater monitoring well MW-18, which is located within 10 feet of MPB. With infrequent bailing of MW-18, a thickened localized smear zone may develop in this well and result in higher concentrations of fuel hydrocarbon contaminants within soils in the immediate vicinity of the monitoring well.

A summary of *in situ* respiration rates and fuel biodegradation rates from the FTA-2 site at Cape Canaveral AFS, is provided at Table 6. The rates at this site have remained fairly uniform during 2 years of air injection bioventing. This uniformity may be the result of the recurring smear zone contamination which occurs with seasonal water table fluctuations. These rates indicate that significant aerobic hydrocarbon biodegradation is still occurring in site soils.

Facility 1748 - Cape Canaveral AFS

Initial and 18-month soil sample results for Facility 1748 are provided in Table 7. Soil samples were not collected at this site during 1-year testing as the original sample depths were below the existing water table. Soil samples were collected after 18 months of operation, although the water table was still elevated, measuring approximately 4 feet bgs. TRPH results changed little during the 18 months of bioventing system operation, and results are thought to be biased upward due to collection of soil samples from within the upper portion of the saturated zone. Total BTEX concentrations at Facility 1748 decreased during the initial 18 months of

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bioventing. Ethylbenzene and xylenes concentrations remained slightly above non-detection limits at the VW and MPA locations.

18-month and 2-year soil gas sampling results at Facility 1748 indicate a 3 order of magnitude reduction in TVH and BTEX concentrations (Table 8). Soil gas samples could not be collected at MPA and MPC during 18-month testing as these MPs were flooded. Since the 5.5-foot depths were still submerged during the 2-year sampling interval, Parsons ES installed new 3-foot monitoring points in the existing MP well boxes at MPA, MPB, and MPC (Figure 4). Although 2-year samples were collected at 3 feet bgs, the results from this sampling event are thought to be comparable to the initial conditions tested in January 1994, since the water table was approximately 1 foot below the tested MP screen during each of these sampling events. Based on soil gas samples from Facility 1748, bioventing has been very effective in reducing TVH and BTEX concentrations.

Respiration and degradation rates for Facility 1748 are shown in Table 9. As previously indicated, elevated water table conditions prevented the evaluation of *in situ* respiration rates at the original MPs (5.5 feet bgs) during 1-year, 18-month, and 2-year testing. However, respiration rates were evaluated at newly installed MPA-3, MPB-3, and MPC-3 during 2-year testing. As with soil gas sampling results, these results are thought to be comparable to initial testing conditions. A slight reduction in rates has occurred as a result of 2 years of bioventing, but *in situ* respiration and microbial biodegradation of existing fuel contaminant residuals appears to be ongoing within soils at the Facility 1748 site.

RECOMMENDATIONS

Based on soil sampling results obtained during the bioventing initiative program and soil gas and respiration results obtained following initial and extended bioventing system operation, it is recommended that bioventing systems at all three sites remain in operation. A significant amount of residual fuel remains in soils at each site, and biodegradation of these residuals is still occurring at significant rates. With the delivery of this letter results report, Option 1 activities are complete for the FTA-2 site at Patrick AFB; and the FTA-2, and Facility 1748 sites at Cape Canaveral AFS. Currently, these three sites have been allocated funding and are scheduled to begin Option 2 closure activities under the AFCEE Extended Bioventing program. Based on the results presented in this report, initiation of Option 2 activities at these three sites appears to be premature.

Operation of these bioventing systems for an additional year (initiating a new Option 1) at each site appears to be a more appropriate course of action than closure soil sampling activities. While source area contamination at each site and the risk presented

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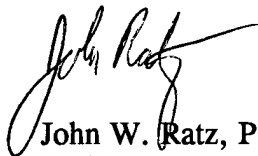
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by elevated BTEX concentrations in site soils has been significantly reduced, further reduction of TRPH levels in soils will likely be needed before initiating closure activities. The current TRPH action level at these sites is on the order of 100 mg/kg.

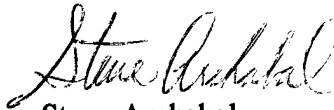
Delivery of this letter results report to AFCCE and the Cape Canaveral AFS/Patrick AFB point of contact completes Parsons ES Option 1 responsibilities for these sites. We would like to discuss the recommendations presented in this report at your earliest convenience. If you have any questions or require additional information, please contact either Steve Archabal or me at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.



John W. Ratz, P.E.
Project Manager



Steve Archabal
Site Manager

cc: Mr. Hugh Houghton, Patrick AFB
D. Tanner (Parsons ES-Austin)
File 727876.26110 Letter Results Report
File 726876.26410 Letter Results Report
File 726876.27210 Letter Results Report
File 726876.01000

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TABLE 1
SITE FTA-2
INITIAL AND 1-YEAR SOIL ANALYTICAL RESULTS
PATRICK AFB, FLORIDA

Analyte (Units) ^{a/}	Sample Locations-Depth (feet below ground surface)					
	HVW-4		MPA-3.5		MPD-3.5	
	Initial ^{b/}	1-Year ^{c/}	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	6,287	3,040	13,250	7,760	11,828	8,610
Benzene (mg/kg)	8	<0.05 ^{d/}	7.6	<0.05	2.7	<0.05
Toluene (mg/kg)	<0.74	<0.05	2.4	<0.05	2.7	<0.05
Ethylbenzene (mg/kg)	6.4	<0.05	2.4	<0.05	3.1	0.052
Xylenes (mg/kg)	43	<0.1	11	<0.099	19	<0.1
Moisture (%)	4.6	7.2	4.4	12.4	3.4	5.3

^{a/} TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

^{b/} Initial soil samples collected on March 11, 1993, but bioventing system operation did not begin until October 1993.

^{c/} 1-year soil samples collected on December 27, 1994.

^{d/} "<" denotes analyte not detected in sample; number shown represents method detection limit.

TABLE 2
SITE FTA-2
INITIAL, 1-YEAR AND 2.5-YEAR SOIL GAS ANALYTICAL RESULTS
PATRICK AFB, FLORIDA

Analyte	Sample Locations-Depth (feet below ground surface)							
	HVV-4		MPA-3.5				MPB-3.5	
	Initial ^{b/}	1-Year ^{a/}	2.5-Year ^{d/}	Initial	1-Year ^{e/}	2.5-Year	Initial	2.5-Year
TVH (ppmv) ^{a/}	10,000	6.6	NS ^{f/}	9,100	56	100	NS	13
Benzene (ppmv)	<0.54 ^{g/}	0.037	NS	<0.54	0.098	0.10M ^{h/}	NS	<0.002
Toluene (ppmv)	<0.54	0.007	NS	<0.54	<0.002	0.039	NS	<0.002
Ethylbenzene (ppmv)	1.7	0.004	NS	1.1	0.004	0.022M	NS	<0.002
Xylenes (ppmv)	5.7	0.02	NS	3.3	0.024	0.033M	NS	<0.002
Analyte	MPC-3.5			MPD-3.5				
	Initial	1-Year	2.5-Year ^{e/}	Initial	1-Year	2.5-Year		
TVH (ppmv)	NS	NS	130	12,000	140	110		
Benzene (ppmv)	NS	NS	0.005	<0.36	0.01	0.028		
Toluene (ppmv)	NS	NS	0.023	<0.36	<0.002	0.015		
Ethylbenzene (ppmv)	NS	NS	0.045M	1.8	0.063	0.005M		
Xylenes (ppmv)	NS	NS	0.048	6.7	0.13	<0.002		

^{a/} TVH=total volatile hydrocarbons: ppmv = parts per million, volume per volume;

^{b/} Initial soil gas samples collected on April 16, 1993, but bioventing system operation did not begin until October 1993.

^{c/} 1-year soil gas samples collected on December 20, 1994. Blower system was shut down approximately 30 days prior to soil gas sampling to allow soil gas to come to equilibrium with soils.

^{d/} 2.5-year soil gas samples collected on May 29, 1996, following approximately 30 days of blower shutdown.

^{e/} Average of duplicate samples.

^{f/} NS = Not sampled.

^{g/} "<" denotes analyte not detected in sample; number shown represents method detection limit.

^{h/} M = Reported value may be biased due to apparent laboratory matrix interferences.

TABLE 3
SITE FTA-2
SUMMARY OF RESPIRATION AND DEGRADATION RATES
PATRICK AFB, FLORIDA

Location-Depth	Initial (April 1993) ^{a/}			6-Month (May 1994) ^{b/}			1-Year (December 1994)			2.5-Year (June 1996) ^{b/}		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/yr) ^{c/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/yr)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/yr)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/yr)	Soil Temperature (°C)
MPA-3.5	0.0076	2,300	18	0.0075	1,700	32	0.0049	730	18	0.0068	1,500	27
MPB-3.5	0.0058	1,800	NS ^{d/}	0.0068	1,500	NS	0.0065	970	NS	0.0073	1,600	NS
MPC-3.5	NS	NC ^{e/}	NS	NS	NC	NS	NS	NC	NS	0.0069	1,600	NS
MPD-3.5	0.0034	1,100	18	0.0063	2,000	30	0.0051	1,500	18	NS	NC	NS

^{a/} Initial respiration test performed in April 1993, but bioventing system operation did not begin until October 1993.

^{b/} Assumes moisture content of the soil is average of initial and 1-year moistures.

^{c/} Milligrams of hydrocarbons per kilogram of soil per year.

^{d/} NS = Not sampled.

^{e/} NC = Not calculated.

TABLE 4
SITE FTA-2
INITIAL AND 1-YEAR SOIL ANALYTICAL RESULTS
CAPE CANAVERAL AFS, FLORIDA

Analyte (Units) ^{a/}	Sample Locations-Depth (feet below ground surface)					
	VW-6		MPA-5.5		MPB-5.5	
	Initial ^{b/}	1-Year ^{c/}	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	30.03	47.3	21.89	18.4	855.4	3,280
Benzene (mg/kg)	< 0.92 ^{d/}	< 0.050	< 0.00043	< 0.050	< 0.36	< 0.050
Toluene (mg/kg)	12.0	< 0.050	0.00035	< 0.050	0.65	< 0.050
Ethylbenzene (mg/kg)	7.20	< 0.050	0.00034	< 0.050	0.70	< 0.050
Xylenes (mg/kg)	15.0	< 0.130	0.015	< 0.130	4.90	< 0.130
Moisture (%)	24.2	17.2	14.5	15.2	4.3	16.6

^{a/} TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

^{b/} Initial soil samples collected on March 26, 1993. Bioventing system operation began in May 1994.

^{c/} 1-year soil samples collected on July 7, 1995.

^{d/} "<" denotes analyte not detected in sample; number shown represents method detection limit.

TABLE 5
SITE FTA-2
INITIAL, 1-YEAR, AND 2-YEAR SOIL GAS ANALYTICAL RESULTS
CAPE CANAVERAL AFS, FLORIDA

Analyte	Sample Locations-Depth (feet below ground surface)					
	VW			MPA-6		
	Initial ^{b/}	1-Year ^{c/}	2-Year ^{d/}	Initial ^{e/}	1-Year	2-Year
TVH (ppmv) ^{a/}	3,400	36	NS ^{f/}	4,400	51	18
Benzene (ppmv)	0.82	< 0.002 ^{g/}	NS	2.3	0.019	0.031
Toluene (ppmv)	< 0.21	< 0.002	NS	< 0.21	0.017	0.027
Ethylbenzene (ppmv)	2.1	0.005	NS	5.0	0.064	< 0.002
Xylenes (ppmv)	4.5	0.044	NS	5.1	0.10	0.028M ^{h/}
Analyte	MPB-6			MPC-6		
	Initial	1-Year	2-Year	Initial	1-Year	2-Year
TVH (ppmv)	NS	550	5,900	NS	NS	200
Benzene (ppmv)	NS	0.027	< 0.052	NS	NS	0.029
Toluene (ppmv)	NS	0.016	0.12	NS	NS	0.050
Ethylbenzene (ppmv)	NS	0.010	< 0.052	NS	NS	0.041
Xylenes (ppmv)	NS	0.070	0.62M	NS	NS	0.38M

^{a/} TVH=total volatile hydrocarbons: ppmv = parts per million, volume per volume;

^{b/} Initial soil gas samples collected on April 19, 1993, but bioventing system operation did not begin until May 1994.

^{c/} 1-year soil gas samples collected on July 7, 1995. Blower system was shut down approximately 30 days prior to soil gas sampling to allow soil gas to come to equilibrium with soils.

^{d/} 2-year soil gas samples collected on May 29, 1996, following approximately 30 days of blower shutdown.

^{e/} Sample result averaged with duplicate.

^{f/} NS = Not sampled.

^{g/} "<" denotes analyte not detected in sample; number shown represents method detection limit.

^{h/} M = Reported value may be biased due to apparent laboratory matrix interferences.

TABLE 6
SITE FTA-2
SUMMARY OF RESPIRATION AND DEGRADATION RATES
CAPE CANAVERAL AFS, FLORIDA

Location-Depth (feet below ground surface)	Initial (April 1993) ^{a/}			6-Month (December 1994) ^{d/}			1-Year (July 1995)			2-Year (June 1996) ^{e/}		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{b/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
MPA-3	NS ^{f/}	NC ^{g/}	NS	0.018	1,600	25.9	NS	NC	32.1	NS	NC	NS
MPA-6	0.0021	210	21.5	NS ^{h/}	NC	NS	0.0068	620	29.8	0.0031	280	25.8
MPB-3	NS	NC	NS	0.017	3,000	23.1	NS	NC	31.2	NS	NC	NS
MPB-6	0.0029	920	21.0	NS ^{h/}	NC	NS	0.0098	690	29.7	0.0095	670	25.4
MPC-3	NS	NC	NS	0.017	3,000	22.2	NS	NC	29.8	NS	NC	NS
MPC-6	0.0043	1,400	20.4	NS ^{h/}	NC	NS	0.026	1,800	28.6	0.018	1,300	24.7

^{a/} Initial respiration test performed in April 1993, but bioventing system operation did not begin until May 1994.

^{b/} Milligrams of hydrocarbons per kilogram of soil per year.

^{c/} Average soil temperature during respiration test.

^{d/} 6-month degradation calculations based upon average of initial and 1-year soil moistures at 6 feet below ground surface.

^{e/} 2-year degradation calculations based upon 1-year soil moisture values.

^{f/} NS = Not sampled.

^{g/} NC = Not calculated.

^{h/} All 6 foot monitoring points were under water during 6-month testing.

TABLE 7
FACILITY 1748
INITIAL AND 18-MONTH SOIL ANALYTICAL RESULTS
CAPE CANAVERAL AFS, FLORIDA

Analyte (Units) ^{a/}	Sample Locations-Depth (feet below ground surface)					
	VW-5.5		MPA-5.5		MPB-5.5	
	Initial ^{b/}	18-Month ^{c/}	Initial	18-Month	Initial	18-Month
TRPH (mg/kg)	18,800	6,600	20,200	24,000	12,600	15,000
Benzene (mg/kg)	< 0.14 ^{d/}	< 0.0025	< 2.8	< 0.061	< 0.54	< 0.062
Toluene (mg/kg)	< 0.14	< 0.0025	< 2.8	< 0.061	< 0.54	< 0.062
Ethylbenzene (mg/kg)	0.51	0.0113	5.1	< 0.490	< 0.54	0.180
Xylenes (mg/kg)	3.7	0.040	8.3	< 0.760	5.1	0.390
Moisture (%)	9.1	18.6	11.8	18.3	6.7	19.4

^{a/} TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

^{b/} Initial soil samples collected on December 30, 1993. Bioventing system operation began in May 1994.

^{c/} 18-month soil samples collected on December 23, 1995.

^{d/} "<" denotes analyte not detected in sample; number shown represents method detection limit.

TABLE 8
FACILITY 1748
INITIAL, 18-MONTH, AND 2-YEAR SOIL GAS ANALYTICAL RESULTS
CAPE CANAVERAL AFS, FLORIDA

Analyte	Sample Locations-Depth (feet below ground surface)					
	VW-3-8			MPA ^{e/}		
	Initial ^{b/}	18-Month ^{c/}	2-Year ^{d/}	Initial	18-Month	2-Year
TVH (ppmv) ^{a/}	510	0.18	NS ^{f/}	740	NS	0.49
Benzene (ppmv)	0.26	< 0.002 ^{g/}	NS	0.91	NS	< 0.002
Toluene (ppmv)	< 0.006	< 0.002	NS	< 0.020	NS	< 0.002
Ethylbenzene (ppmv)	1.2	< 0.002	NS	3.6	NS	< 0.002
Xylenes (ppmv)	2.6	< 0.002	NS	3.9	NS	< 0.002
	MPB-3			MPC ^{e/}		
	Initial	18-Month	2-Year	Initial	18-Month	2-Year
TVH (ppmv)	NA ^{b/}	NA	1.6	1,000	NS	1.3
Benzene (ppmv)	NA	NA	0.002	3.3	NS	< 0.002
Toluene (ppmv)	NA	NA	0.006	< 0.10	NS	< 0.002
Ethylbenzene (ppmv)	NA	NA	0.003	5.5	NS	< 0.002
Xylenes (ppmv)	NA	NA	0.018	3.4	NS	< 0.002

^{a/} TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume;

^{b/} Initial soil gas samples collected on January 14, 1994.

^{c/} 18-month soil gas samples collected on December 22, 1995. Blower system was shut down approximately 30 days prior to soil gas sampling to allow soil gas to come to equilibrium with soils.

^{d/} 2-year soil gas samples collected on May 30, 1996, following approximately 30 days of blower shutdown.

^{e/} Initial soil gas sample from this monitoring point (MP) collected at 5.5 feet below ground surface. No sample collected at 18 months; the MP was flooded. 2-year sample collected at newly installed 3 foot MP depth.

^{f/} NS = Not sampled.

^{g/} " < " denotes analyte not detected in sample; number shown represents method detection limit.

^{h/} NA = Not applicable; MPB-5.5 was not sampled during initial or 18-month testing, and MPB-3 was not installed until 2-year sampling event.

TABLE 9
FACILITY 1748
SUMMARY OF RESPIRATION AND DEGRADATION RATES
CAPE CANAVERAL AFS, FLORIDA

Location-Depth (feet below ground surface)	Initial (January 1994) ^{a/}			18-Month (December 1995) ^{d/}			2-Year (June 1996) ^{f/}		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{b/}	Soil Temperature (°C) ^{c/}	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
MPA-3 ^{g/}	NA ^{b/}	NA	NA	NA	NA	NA	0.0024	280	NS ^{i/}
MPA-5.5	0.0027	640	22.1	NS	NC ^{j/}	NS	NS	NC	26.6
MPB-3 ^{g/}	NA	NA	NA	NA	NA	NA	0.0019	180	NS
MPB-5.5	0.0025	840	NS	NS	NC	NS	NS	NC	NS
MPC-3 ^{g/}	NA	NA	NA	NA	NA	NA	0.0037	350	NS
MPC-5.5	0.0027	950	23.1	NS	NC	NS	NS	NC	27.3
VW-3-8	NS	NC	NS	0.0023	240	NS	NS	NC	NS

^{a/} Initial respiration testing performed in January 1994, but system operation did not begin until May 1994.

^{b/} Milligrams of hydrocarbons per kilogram of soil per year.

^{c/} Average soil temperature during respiration test.

^{d/} Unable to perform respiration testing during 6-month and 1-year site visits; all monitoring points were flooded due to elevated water table.

^{e/} During 18-month visit, unable to perform respiration tests at all monitoring points except the vent well due to flooding/elevated water table.

^{f/} All original (5.5 foot deep) monitoring points were flooded during 2-year site visit due to elevated water table.

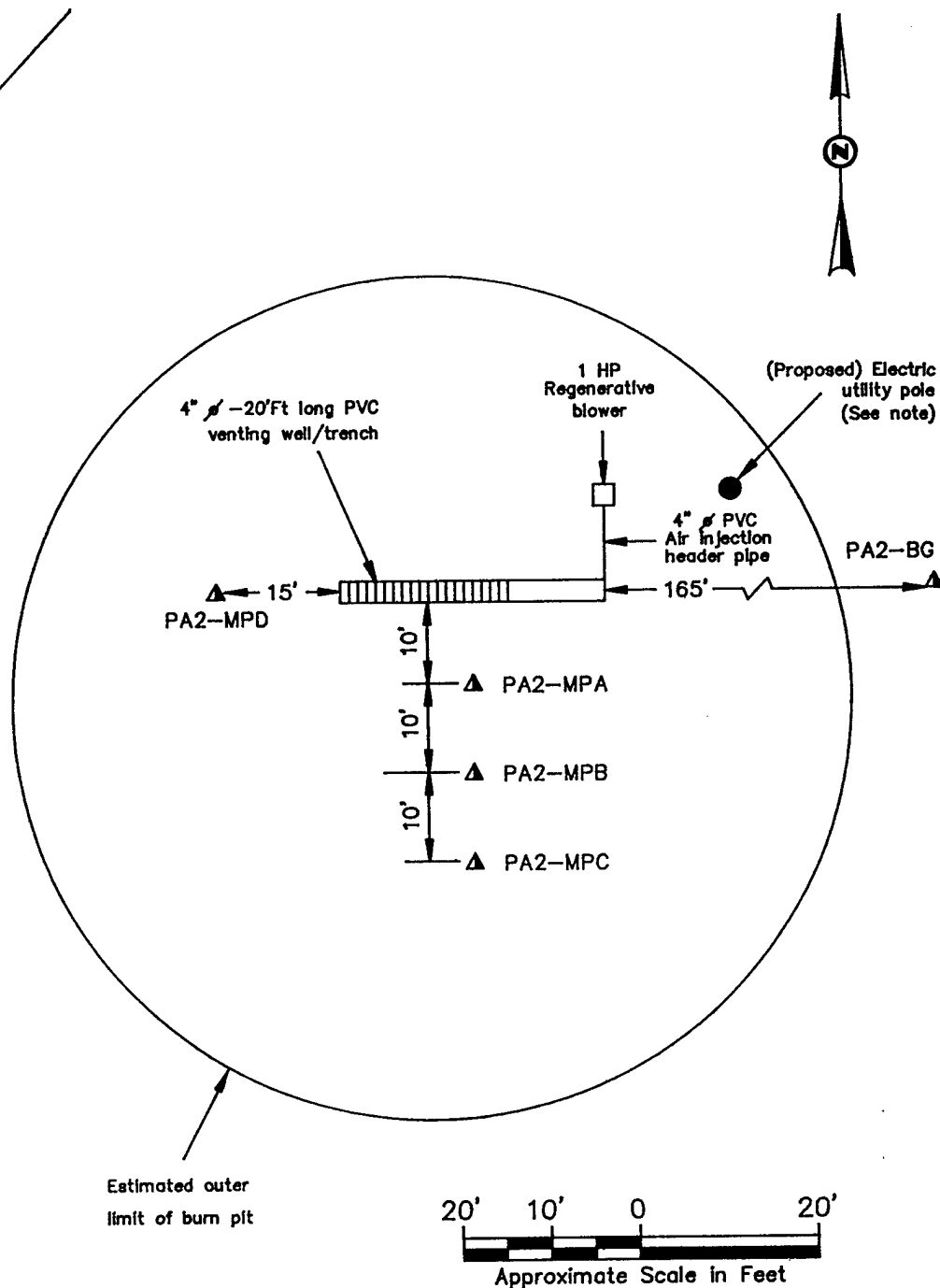
^{g/} 3 foot deep monitoring points were installed during 2-year site visit.

^{h/} NA = Not applicable.

^{i/} NS = Not sampled.

^{j/} NC = Not calculated.

BANANA RIVER



LEGEND

PA2-MPA Permanent soil vapor/pressure monitoring point.
▲

NOTE: Interim pilot test performed prior to permanent electric hookup

FIGURE 1

**AS-BUILT VENT WELL,
MONITORING POINT
AND BLOWER LOCATIONS**

FT A-2
Patrick AFB, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

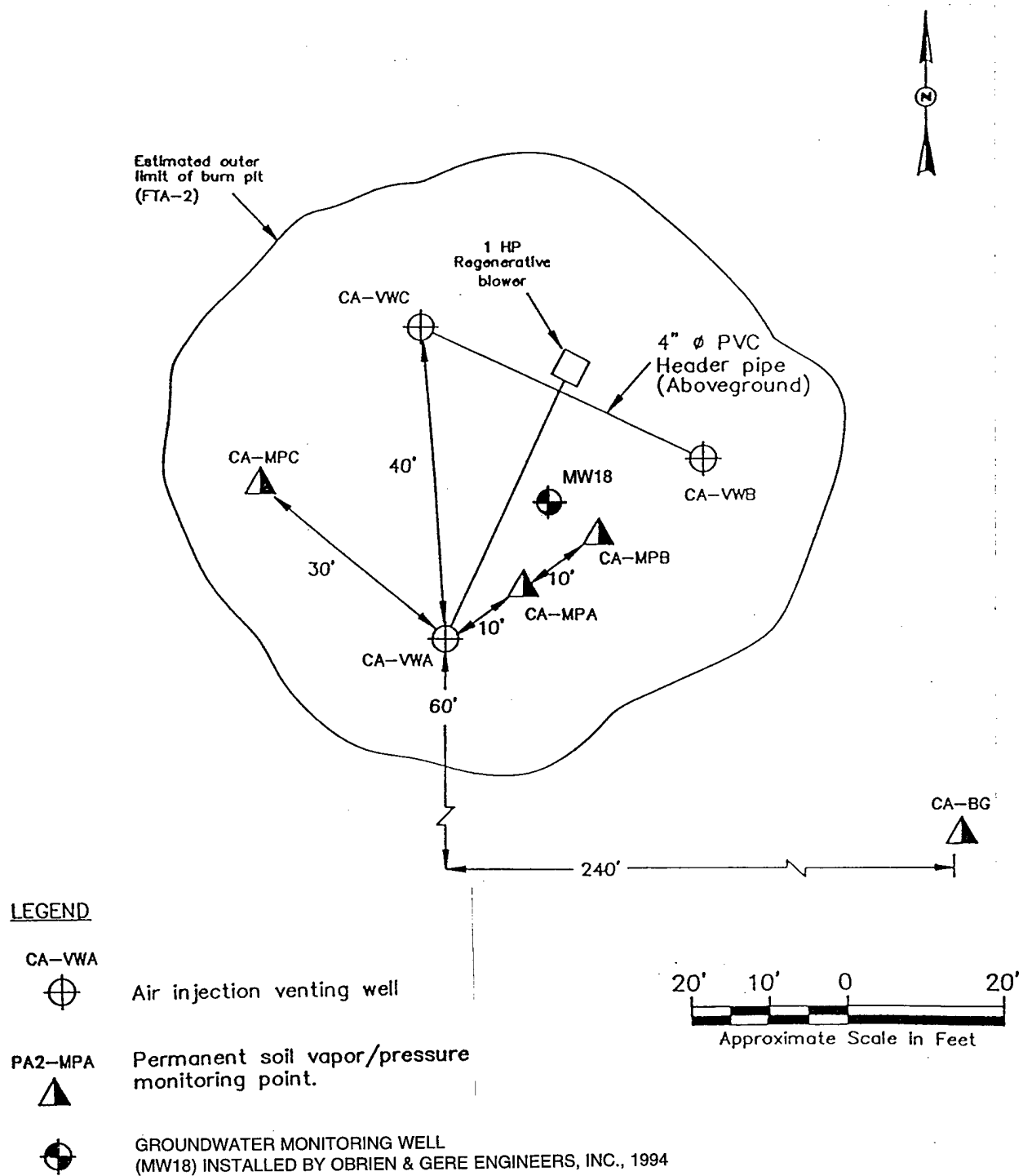


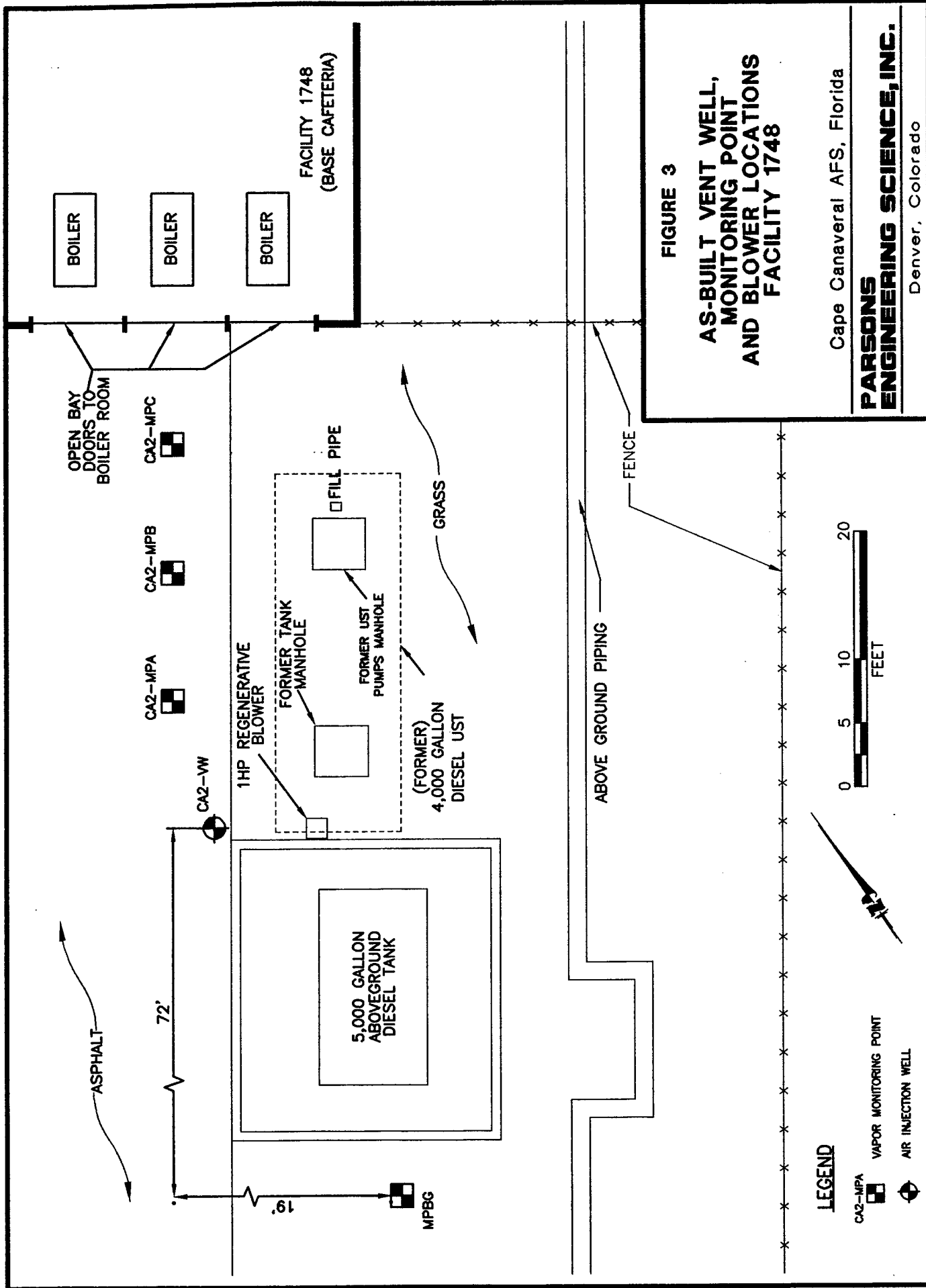
FIGURE 2

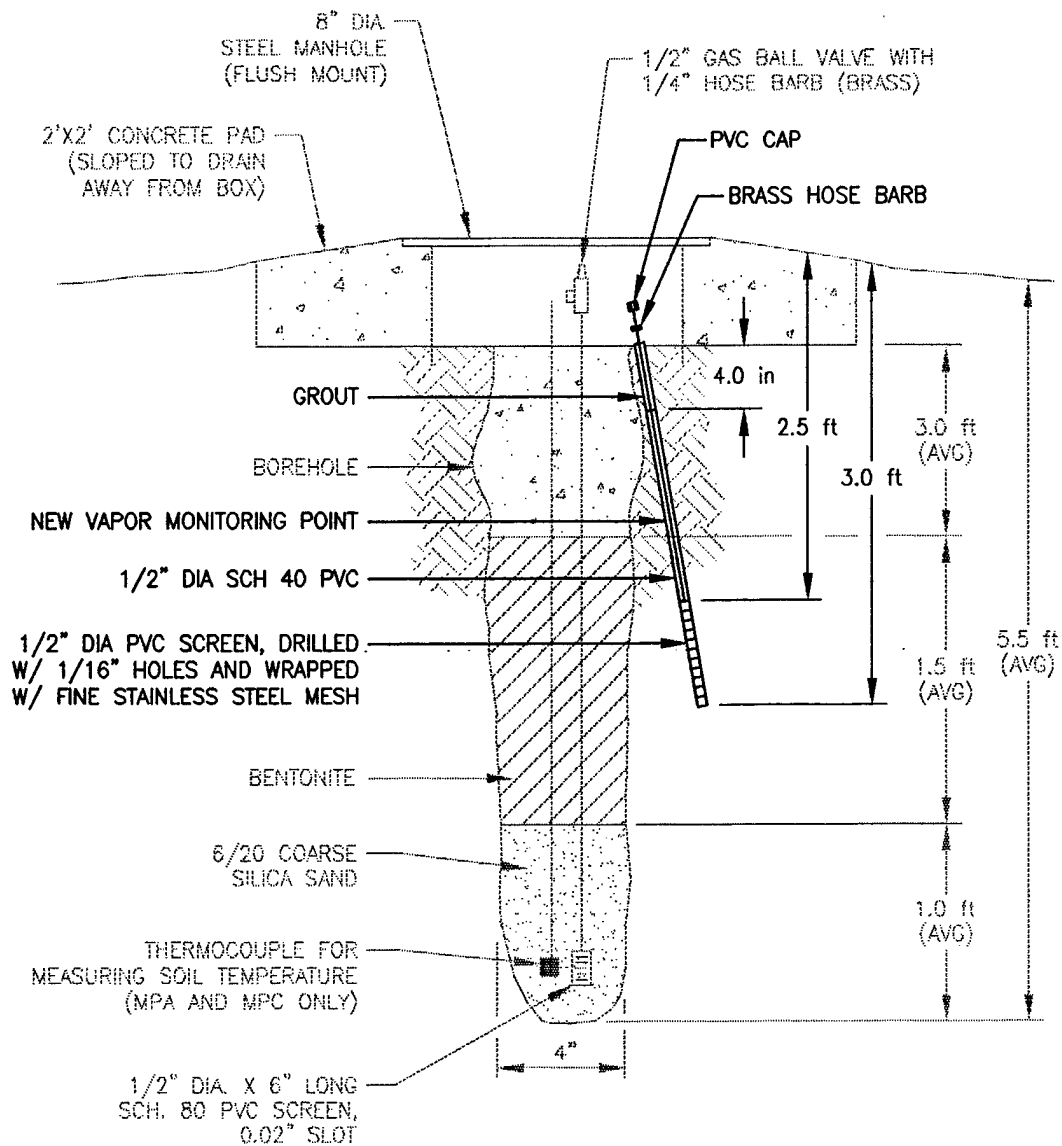
**AS-BUILT VENT WELL,
 MONITORING POINT
 AND BLOWER LOCATIONS**

FT A-2
 Cape Canaveral AFS, Florida

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MONITORING POINT CONSTRUCTION SPECIFICATIONS

Monitoring Point No.	Borehole Depth (FT)	Screen Interval (Feet BLS)
MPA-3.0	3.0	2.5-3.0
MPB-3.0	3.0	2.5-3.0
MPC-3.0	3.0	2.5-3.0
MPA-5.5	5.5	5.0-5.5
MPB-5.5	5.5	5.0-5.5
MPC-5.5	5.5	5.0-5.5
BACKGROUND MONITORING POINT		
MP-3.0		2.5-3.0
MP-5.5	5.5	5.0-5.5

NOTE:

AS-BUILT BACKGROUND MP WAS CONSTRUCTED THE SAME AS MP'S AT FACILITY 44625D/E.

NOT TO SCALE

FIGURE 4 MODIFIED AS-BUILT PERMANENT MONITORING POINT CONSTRUCTION DETAIL FACILITY 1748

Cape Canaveral AFS, Florida

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